

Meeting Discussion

This section documents questions or points highlighted during the discussion that may not be covered in the viewgraph materials. Notes recorded by Hank Price 303-384-7437, henry_price@nrel.gov.

Rod Mahoney – Receiver Developments

- Is concentration really an issue with LS-3/LS-2?
 - Kearney – small difference between the two designs
 - Cohen – Alignment more a problem in LS-2

Michael Geyer - EuroTrough since 1998

- EuroTrough
 - Goal of EuroTrough is a 20% cost reduction
 - EuroTrough has 2 phases – \$3M (1/01)/\$2M Euro (12/02)
 - The EuroTrough is an open architecture design – like the IBM PC
 - Another German company is developing an LS-2 type collector
- AndaSol32 – Spanish Project with EuroTrough (near PSA)
 - Rankine cycle plant – HTF and DSG subfields
 - 235,440m² – 432 EuroTrough Collectors – 54 loops
- Spanish Market
 - Spanish Tariff for CSP is currently 7-8¢/kWh (not the 24¢/kWh reported last year)
 - 200 MWe of CSP plants planned for Spain
 - Projects are expected to need 70% grants (looking for 70% of these from EU)

IST – Collector Development - Ken May

- SEECOT Benefit – Low cost capacity addition (competitive with fossil)
- Concentrator Development – Reflector is part of structure
 - \$168/m² – 2000m² field
 - 40% cost reduction goal – installed cost of \$100/m²
 - increased performance

Duke – Collector Development

- Duke designs use LS-2 as design basis
- Secondary reduces the required tolerances of the concentrator

Bruce Kelly – Thermal Storage

- Oil steam generator is favored over salt steam generator
- Oil/Salt heat exchanger safety is a key, though addressable, issue
- Rankine plant storage cost is \$25-32/kWh (compared to \$10-15/kWh for tower)
- ISCCS Low Impact – Storage cost \$35-40/kWh
- ISCCS High Impact – Storage cost \$24-30/kWh (18% SF with 90% CC CF)
- TS at \$25/kWh results in no reduction in LEC but allows dispatch of solar power.

Jim Pacheco – Thermocline Thermal Storage Systems

- Safety issues not significant
- Good filler materials are being identified

Mary Jane Hale – TS Directions

- Now have a viable thermal storage option (\$27-32/kWh)
- Thermocline could option could reduce cost further
- Advanced Storage – Direct Sensible Heat Storage
- Generally – Near-term option is consistent with the Roadmap TS Goals for 2005
- Richard Spencer Comment – Risk definition is from the Developer, are they comfortable?

Bruce Kelly – ISCCS Design Optimization

- Most efficient use of solar energy is in steam generation – therefore if you use solar energy for anything else it is less efficient.
- Inherent limits define how much solar you can add before conversion efficiencies are impacted (2-7%)
- Higher solar contributions will result in sharp reductions in conversion efficiency.
- Turbine is a volume flow device which doesn't change so efficiency is relatively constant
- Design Recommendation:
 - F series gas turbine
 - Maximum solar contribution 7-8% (50-75% bigger ST); use TS for larger SF

Michael Geyer - DISS

- Pressure drops are much lower than expected
- Ball joints are working
- Circumferential HCE temperature difference is less than 20 C
- Problem experienced with thermo couple installation in HCEs.
- Data from June - DSG maintained Pout constant with flow control under severe radiation changes
- Measurement Techniques - Labs need to determine how to measure flux and temperature distribution on absorber tubes, and alignment of collectors.

Richard Spencer – GEF Project Status

- Egypt – trough or air tower likely (molten-salt not excluded)
 - Will assume 3-4 hrs of duct firing
- India – KfW taking project forward
 - EPC/O&M bidding
- Mexico
 - 40 MW solar 300 MW CC
 - SMA feasibility report – add duct firing
 - Bidding docs by CFE – September (trough focus)
 - CFE restructuring in progress
- Morocco
 - Recruiting consultants
 - 120 MW capacity gas fired ISCCS
- When will 4 plants be completed? Approximately 2004
- Can GEF guarantee plants will be built? NO

Vahab Hassani. – Modular Solar Electric Power Systems

- 400F may be upper limit on fluids

Panel Discussion Points

- Choice of working fluid
- Availability of components
- Development of new cycles
- Issues for modular solar fields
- Automation of solar field operation
- Balance between cost and efficiency
- Identification of potential markets
- Next steps?

James Dickson - Exergy

- Optimized from existing Kalina cycle designs – KS-33 chosen for analysis
- Cold temperature constraint (440F) limited cycle selection
- Kalina system in Japan is in operation
- 30.4% at 580F and 31.1% at 735F
- Standard equipment available

Bill Batton – Barber Nichols

- Combined efficiency is most important
- Need engines that can work at higher temperatures
- Fluid selection is important – Toluene may be a promising option.

John Burgman – Bibb & Associates

- 2x5MWe ORC Geothermal system shown
- Use existing ORC cycles for troughs in a small modular (1-10 MWe)
- Conventional rules of wisdom for geothermal applications do not necessarily hold true for solar thermal plants
- Want high temperature for high efficiency, but want to keep the condensing above ambient.
- Simple Cycle – Normal Butane, low efficiency
- Cascade Cycle – Cyclohexane, normal butane – improved efficiency but increased complexity and cost
- Improved cascade – with higher SF return temperature
- From a technical sense this is completely practical.
- Commercially proven technology – some changing in design and optimization

Randy Gee – Duke Solar

- Troughs proven – lots of experience
- Must combine collector and power cycle to get overall efficiency
- Improving power cycle efficiency is the best way to reduce SF costs
- By increasing power cycle efficiency from 45% to 55% of Carnot, you can increase power cycle cost effectiveness by 50%

Edan Prabhu - Potential Markets

- A lot of thought has gone into solar side, not a lot has been done to optimize the power cycle
- Low temperature storage – allows production at night which will help power cycle efficiency due to cooler temperatures.
- The value of power is higher for off grid applications (Grid 3-10 cents, Off-grid 10-30 cents)
- Storage proven for temperatures at 550F and below.
- Small modular plants could be developed much quicker
- Concept uses proven technologies which works much better for financing
- 100s MWe of trough and geothermal – good integration options
- Market place is much closer to ready for this than large trough systems.

What is the commercial availability of equipment? (Question to panel)

- Every thing available except turbine for small systems (<1MWe)
- Exergy – 7-10 MWe minimum for high turbine efficiency
- Ormat has built systems in the 500-4500 kWe range.
- Cascade Cycle Optimization
- Operation at off design conditions – solar has daily cycle. Storage has impact. Efficiency does suffer.
- Heat rejection is the real big cost. (cooling tower costs for air cooling)
- Turbine costs could reduce with production (\$900-1500/kWe)
- Looking at hybridization – ??
- ORMAT – interested at lower temperature
- BN is interested

Panel Discussion - Action Items

- Working fluids
- Exergy – More optimization
- Commercialization – does anyone want to put out a real bid document?
- Bibb – Need energy developer to make a project happen – few months on details. More a question of economics. Need more info on real opportunities